1487-16

10 March 1988

Ontario Waste Management
Corporation
2 Bloor Street West
11th Floor
TORONTO, Ontario
M4W 3E2

Attention: Ms. M.L. Johnson

OWMC EA Documentation

Dear Sirs:

We enclose one copy of a report entitled 'Survey of Mobile Treatment Technologies for Industrial and Hazardous Waste' prepared by Engineering-Science.

Please retain for your files.

Yours truly,

M.M. DILLON LIMITED

GJK:lly
encl:

G.J. Komar, P.Eng.
for J.R. Balfour, P.Eng.
Project Manager

TABLE OF CONTENTS

EPA/RCRA OFFICE

		Page
SECTION 1	INTRODUCTION	1-1
	PROJECT BACKGROUND	1-2
	CRITERIA FOR DEFINITION OF MOBILE TECHNOLOGY	1-15
	ORGANIZATION OF REPORT	1-16
SECTION 2	THERMAL TREATMENT SYSTEMS	2-1
	MOBILE THERMAL TECHNOLOGIES	2-1
SECTION 3	PCB DESTRUCTION PROCESSES	3-1
	NEW PCB DESTRUCTION TECHNOLOGIES	3-3
SECTION 4	PHYSICAL/CHEMICAL TREATMENT SYSTEMS	4-1
	PHASE SEPARATION TECHNOLOGIES	4-2
	ACTIVATED CARBON	4-12
SECTION 5	SOLIDIFICATION/STABILIZATION TECHNOLOGIES	5-1
SECTION 6	CONCLUSIONS AND RECOMMENDATIONS	6-1

SECTION 1
INTRODUCTION

This report presents a brief summary of the findings and conclusions of a survey of mobile treatment technologies for industrial and hazardous wastes recently completed by Engineering-Science (ES) for the Ontario Waste Management Corporation (OWMC). The original survey was commissioned by OWMC as part of an ongoing effort to design and construct a regional industrial and hazardous waste treatment facility for the Province of Ontario. Its purpose was to identify mobile technologies which could provide short-term waste treatment at a number of generation points throughout the Province, thereby reducing or eliminating the need for construction of a full-scale and permanently located facility. Widespread availability of suitable mobile technologies could affect the required size of the regional facility, its schedule for completion, and the nature and diversity of waste processing steps to be incorporated.

A comprehensive list of mobile or potentially mobile waste treatment technologies was developed and reviewed as part of this project. Many such technologies were identified. Most, however, were found to be inappropriate for consideration or implementation by the Province because of one or more of the following reasons:

- Data derived from full-scale commercial application of the technologies were not sufficiently developed to allow adequate process evaluation;

- Current limitations on the size or availability of equipment precluded full-scale application in the Province in the near future;

- The technologies would not be effective in treating the high strength waste streams likely to be stored and accumulated at various industrial sites; and

- Many of the mobile treatment technologies can only accomplish a change in phase or increase in concentration of the waste material. Although such changes may be advantageous in reducing the volume of waste handled and the overall cost of waste treatment, no detoxification of the waste is achieved. Subsequent on-site or off-site treatment will, therefore, still be required.

Nevertheless, several mobile systems have been demonstrated to a sufficent degree to allow consideration as potentially usable within the Province. These technologies are identified and described in the following report.

PROJECT BACKGROUND

OWMC was originally chartered to provide facilities for the treatment of hazardous and industrial wastes within the Province of Ontario and to facilitate the design, construction and operation of those facilities. As part of its initial efforts, OWMC retained the Proctor and Redfern Group, a consulting engineering firm, to identify and evaluate the availability of mobile treatment technologies which could provide some or all of this treatment capacity. This draft report was completed in 1982 and entitled, "Survey of Mobile Treatment Technologies for Special Wastes." The draft report concluded that, with the exception of several mobilized technologies for the destruction of polychlorinated biphenyls (PCBs), mobile technologies for the treatment, destruction or detoxification of various OWMC-identified waste groups were not available on the commercial scale. The study thereby provided a greater impetus for the construction of the regional waste treatment facility.

Five years have now passed since the completion of the original study. OWMC has requested ES to update that study to determine if additional mobile treatment technologies have been developed to the point where they should be considered and incorporated into the overall waste management strategy for the Province. This report briefly summarizes the results of that follow-on survey and describes the methodology used to develop and complete it. A more detailed report of the various technologies reviewed can be prepared at OWMC request if judged necessary and appropriate. The cost of preparing this report was not included in the original project scoping.

This project to evaluate mobile waste treatment technologies was carried out in three phases. In the first phase, a list of available sources of information on mobile hazardous and industrial waste treatment technologies, including regulatory agency resource documents, recent federally-sponsored technical development programs, technical literature, recognized experts and product suppliers, etc., was compiled and internally reviewed for thoroughness. These sources of information were reviewed or contacted as appropriate so that a "master list" of potentially appropriate waste treatment technologies could be developed (see Figure 1-1). In this list the various processes and vendors were organized into primary treatment categories similiar to those used in the original 1982 report.

The second phase of this project consisted of the development of a standardized questionnaire for use during telephone interviews of the various equipment and technology suppliers. This questionnaire (see Figure 1-2) was intended to determine the current commercial status of the technology, the mobility of the units (as defined by transportation, on-site mobilization and ancillary facilities requirements), and expected performance. The standardized questionnaire format was used during conversations with supplier and technical representative contacts to the extent possible, although deviations were sometimes necessary to account for technology-specific conditions.

The third phase of the project involved the compilation of the available information for the various technologies. ES specialists within each of the identified technical areas were selected to coordinate the information gathering activities. Technology assessments were developed strictly on the basis of information offered by the suppliers themselves or by review of technical literature or product bulletins. Time constraints for the completion of this project precluded on-site visits to confirm the information supplied. On-site visits are recommended before serious consideration is given towards implementing any of these technologies in the Province.

FIGURE 1-1

MASTER LIST OF MANUFACTURERS/SUPPLIERS

Type of Technology	Firm Name	Contact/Telephone
Physical/Chemical	Acurex Cincinnati, OH	Jim Thompson 415-964-3200
	Advanced Mineral Technologies 5920 McIntyre Street Golden, CO 80403	303-279-6982
	American Mobil Oil Purification 233 Broadway, 17th Floor New York, NY 10279	
	American Toxic Disposal, Inc. 560 Seahorse Drive Waukegan, IL 60085	William Meenan 312-336-6067
	Andco Environmental Processes, Inc. 595 Commerce Drive Amherst, NY 14150	Joseph Duffy 716-691-2100
	Bird Environmental Systems 100 Neponset Street South Walpole, MA 01071	Neil D. Policow
	Calgon Carbon Corporation P. O. Box 717 Pittsburgh, PA 15230	Joseph Rizzo 412-787-6700
	Carbon Air Services P. O. Box 5117 Hopkins, MN 55343	Bruce Anderson 612-935-1844
	Chemical Processors, Inc. 5501 Airport Way - South Seattle, WA 98108	Ron West 206-767-0350
	Chemical Waste Management 150 West 137th Street Riverdale, IL 60627	Peter Daley 312-841-8360
	Critical Fluid Systems 25 Acorn Park Cambridge, MA 02140	Peter Dunlap 617-492-1631

FIGURE 1-1 (Continued)

MASTER LIST OF MANUFACTURERS/SUPPLIERS

Type of Technology	Firm Name	Contact/Telephone
	DETOX, Inc. Dayton, OH 45459	Evan Nyer 513-433-7394
	Ecolochem, Inc. 4545 Patent Road P.O. Box 12775 Norfolk, VA 23502	Richard Smallwood 800-446-8004
	Enzotech, Inc. 11550 Vanowen Street North Hollywood, CA 91605	Doug Smith 818-982-4895
	Envirochem Waste Management Services P. O.Box 10787 Raleigh, NC 27605	Jerry Deakle 919-469-8490
	Holtz Bio-Engineering 186750 Adams Court Morgan Hill, CA	Barry Holtz 408-779-2937
	Industrial Innovations, Inc. P. O. Box 830 Stockton, CA 95201	Alfred Abila 209-462-8241
	Interim Dewatering Services 200 Monroe Turnpike Monroe, CT 06468	203-261-4458
	IT Corporation 4575 Pacheco Blvd. Martinez, CA 94553	Ed Sirota 415-228-5100
	Kipin Industries 513 Green Garden Road Aliquippa, PA 15001	Peter Kipin 412-495-6200
	Metropolitan Environmental P.O. Box 609 Celina, OH 45822	419-586-6638

FIGURE 1-1

MASTER LIST OF MANUFACTURERS/SUPPLIERS

Type of Technology	Firm Name	Contact/Telephone
	Mobile Solvent Reclaimers RR 1 St. Joseph, MO 64507	Larry Lambing 816-232-3972
	MTA Remedial Resources 1511 Washington Avenue Golden, CO 80401	303-279-4255
	National Applied Scientific Systems 501 E. King Street P. O. Box 1988 York, PA 17405	Francis McGinnis 717-846-3685
	PPM Inc. 10 Central Avenue Kansas City, MO 66118	Fred Labser 913-621-4206
	Pressure Filtration Specialists, Inc. 400 Arbor Lake Drive P. O. Box 23657 Columbia, SC 29224	Mike Jump 803-735-1510
	Resource Conservation Co. 3630 Cornus Lane Ellicott City, MD 21043	Lenny Weimer
	Resources Conservation Co. 3101 NE Northup Way Bellevue, WA 98004	206-828-2400
	Rexnord C.R.I.C. 5103 West Beloit Road Milwaukee, WI 53201	Richard Osantowski 414-643-2762
	Solidtek 5371 Cook Road Morrow, GA 30260	Ed Shuster 404-361-6181

FIGURE 1-1 (Continued)

MASTER LIST OF MANUFACTURERS/SUPPLIERS

Type of Technology	Firm Name	Contact/Telephone
	Sunohio 1700 Gateway Blvd., S.E. Canton, OH 44707	Doug Toman 216-452-0837
	Tetra Recovery Systems 1121 Boyce Road, Suite 1300 Pittsburgh, PA 15241	Ogden Clemens 412-777-5235
Solidification	Bethlehem Steel Bldg. H-Room A110 Bethlehem, PA 18016	Robert M. McMullan 215-694-2424
	Chemfix Inc. 1675 Airline Highway P.O. Box 1572 Kenner, LA 70063	Robert A. Phelan 504-467-2800
	Chemical Waste Management Riverdale Center 150 W. 137th Street Riverdale, IL 60627	Peter Daley 312-841-8360
	Envirite Field Services 600 Germantown Pike Plymouth Meeting, PA 19462	Bill Howard 215-825-8877
	Envirochem Waste Management 975 Walnut Street Cary, NC 27511	Jerry Deakle 919-469-8490
	Hazcon Inc. P. O. Box 947 Katy, TX 77492	Roy Funderburk 713-391-1085
	Resource Recovery of America, Inc. Executive Plaza, Suite 23 4406 South Florida Avenue Lakeland, FL 13303	Robert O'Kinbart 813-644-7700
	Solidtek Systems, Inc. 5371 Cook Road Morrow, GA 30260	Ed Shuster 404-361-6181

FIGURE 1-1 (Continued)

MASTER LIST OF MANUFACTURERS/SUPPLIERS

Type of Technology	Firm Name	Contact/Telephone
	Velsicol Chemical Corporation 2603 Corporate Avenue Suite 100 Memphis, TN 38132	Charles Hanson 901-345-1788
	Westinghouse Hittman Nuclear 9151 Runsey Road Columbia, MD 21045	Robert Connor 301-964-5043
	Westinghouse Waste Technology Services Division P. O. Box 286 Madison, PA 15663	 412-722-5600
Thermal	DETOXCO 2700 Ygnacio Valley Road Walnut Creek, CA	Robert McMahon 415-930-7997
	ENSCO Environmental Services First Tennessee Bank Bldg. Third Floor Franklin, TN	Robert McCormack 615-794-1351
	GA Technologies Inc. P. O. Box 85608 San Diego, CA 92138	Harold Diot 619-455-3000
	Haztech 5280 Panola Industrial Blvd. Decatur, GA 30035	Saul Furstein 404-981-9332
	Intermation Waste Energy Systems 2150 Kienlen Street St. Louis, MO 63121	D.C. Brown 314-389-7275
	John Zink Services 4401 S. Peoria Avenue P.O. Box 702220 Tulsa, OK	Kenneth Hastings 918-747-1371

FIGURE 1-1 (Continued)

MASTER LIST OF MANUFACTURERS/SUPPLIERS

Type of Technology	Firm Name	Contact/Telephone
	MAECORP Inc. 17450 South Halsted Street Homewood, IL 60430	Hank Mandosa 312-957-7600
	Modar Inc. 320 Wilcrest Street, Suite 220 Houston, TX 7042	Fred Sieber 713-785-5615
	OH Materials P.O. Box 551 Findley, OH 45839	Sam Insallaco 419-423-3526
	Rollins Environmental Services 1 Rollins Plaza Wilmington, DE 19899	Bill Philipbar 302-479-2700
	Shirco Infrared Systems Inc. 1195 Empire Central Dallas, TX 75247-4301	George Hay 214-630-7511
	Sitex Corp. 231 Biniston, #560 Clayton, MO 63105	314-862-0010
	Trade Waste Incineration - Division of Chemical Waste Management 8000 Maryland, Suite 4400 St. Louis, MO 63105	A. J. McCoy 314-727-5040
	TWI 800 Maryland, Suite 400 St. Louis, MO 63105	A. J. McCoy 314-727-5040
	VerTech Treatment Systems 12000 Pecos Street Denver, Co 80234	Gerald Rape 303-452-8800
	Westinghouse Plasma Systems P.O. 350 Madison, PA 15563	Bill Mellili 412-722-5637

FIGURE 1-1 (Continued)

MASTER LIST OF MANUFACTURERS/SUPPLIERS

Type of Technology	Firm Name	Contact/Telephone
	Winston Technology 6920 N.W. 44th Ct. Lauderhill, FL 33319	Patrick Philips 305-748-1769
	Zimpro Inc. Military Road Rothchild, WI 54474	J. Robert Nicholson 715-359-7211

FIGURE 1-2

QUESTIONNAIRE FOR REVIEW OF MOBILE TREATMENT TECHNOLOGIES
TOPICS FOR REVIEW AND CONSIDERATION

A. Company Contacts

Business Development	Technical Advisor
Name	
Address	
Telephone	

B. Process Description

1. Technology area (Incineration, Immobilization, Chemical Oxidation, Extraction, etc.)

2. Specific technology identification (e.g., lime-pozzolon solidification, infrared incineration, etc.)

3. Amenability of waste groups to treatment technology

   a) "Chemical" characteristics which are amenable to treatment (e.g., organic wastes, as specific as possible using the 13 waste groups from OWMC)

   b) Physical characteristics of the waste which must be met if treatment is to be applied (i.e., dilution, size limitations, percent organic matter, BTU/lb, etc.)

      1) What degree of pre-treatment is necessary for containerized waste - are facilities available for container detoxification, joint destruction with waste?

   c) What physical characteristics of the waste would preclude consideration of the technology?

   d) Concentration, compound diversity limitations limiting waste application

   e) Prepare a listing of OWMC groups (broken down into subgroups as appropriate) which can be treated by this technology

FIGURE 1-2, Continued

QUESTIONNAIRE FOR REVIEW OF MOBILE TREATMENT TECHNOLOGIES
TOPICS FOR REVIEW AND CONSIDERATION

C. Equipment Type and Size

1. Identify major processing steps (include pre-treatment processing [including container handling] and post-treatment [side-stream or byproduct handling or treatment] requirements)

2. Identify major equipment requirements for each processing step (Note: This should be discussed in the level of specificity appropriate for the technology under consideration - e.g., an incinerator supplier might discuss all the major components of the process such as the kiln, after-burner, air-scrubber, etc.; solidification supplier may disuss mixing tanks, chemical addition methods, storage and curing holding requirements, etc.)

3. Describe the current status of mobility

   a) Describe units which are now mobile

   b) Describe number of units, how they are combined into a complete system at the processing site

   c) Describe current mode of transportation - how these units are brought onto the site

   d) Describe supplemental facilities which must be provided for proper unit function and which are

      1) Mobile
      2) Transportable
      3) Must be permanently installed at the site

4. On-site installation requirements for mobile/transportable units

   a) Describe total assembled package now available (mobile/transportable units only)

      1) Number of units/trailers
      2) Utility Requirements and necessary on-site facilities requiring construction
      3) Set-up sequence of activities/average time for set-up/shakedown and other steps prior to actual waste treatment operations
      4) Dimensions/footprint - special on-site access or placement restrictions (i.e., slope, vertical clearances)
      5) Other special access restrictions - clearances, road weight restrictions, etc.

FIGURE 1-2, Continued

QUESTIONNAIRE FOR REVIEW OF MOBILE TREATMENT TECHNOLOGIES
TOPICS FOR REVIEW AND CONSIDERATION

---

b) De-mobilization requirements

1) Time and degree of difficulty
2) Waste or construction materials which must remain on-site

D. Performance Criteria

1. Primary Waste Processing Steps

a) Primary acceptability criteria for processed waste

b) Degree of compliance with existing regulatory standards

2. Pre-treatment Processing Steps

a) Primary acceptability criteria for processed waste

b) Degree of compliance with existing regulatory standards

3. Post-treatment (Side-stream or waste product handling steps)

a) Primary acceptability criteria for processed waste

b) Degree of compliance with existing regulatory standards

E. Operational History

1. Pilot-Scale Demonstrations

a) Waste types and locations

b) Describe performance monitoring/length of operational period and overall "similarity" to expected full-scale operating conditions

c) Describe size/flow of unit

d) Describe operational problems and difficulties

2. Full-Scale Demonstrations

a) Waste types and locations

b) Describe size/flow of unit - time of operation

c) Describe operational problems and difficulties

FIGURE 1-2, Continued

QUESTIONNAIRE FOR REVIEW OF MOBILE TREATMENT TECHNOLOGIES
TOPICS FOR REVIEW AND CONSIDERATION

---

d) Discuss degree of compliance with performance criteria (time of operation, etc.)

e) Overall cost of a unit price basis or overall - provide detail for capital and operating cost including on-site construction, pre- and post-treatment and residue disposal

f) Describe current permit status - for which types of waste is the unit restricted and why?

1) are there any plans to obtain the necessary permits?
2) difficulties in obtaining permits in the past

3. Describe current equipment availability

4. Describe overall commercial status and whether this technology meets the criterion of 12 months of full-scale operation

F. Availability of Technical Literature/Independent Assessment backing up the manufacturer's claims

1. Client References

CRITERIA FOR DEFINITION OF MOBILE TECHNOLOGY

Many of the technologies used to date for the treatment of industrial or hazardous wastes can easily be incorporated into mobile systems with only slight modifications in design. This is especially true of physical waste separation processes, which rely on standardized technology and equipment which can be truck-mounted with a minimum of effort. It is not the intent of this report to evaluate these technologies but rather to identify those technologies which have been commercially demonstrated in actual mobile system applications. By definition of OWMC, such technologies can only be considered as commercially demonstrated if they have at least one year of full-scale operating experience. Other mobile treatment technologies at or near the full-scale demonstration status, with units either under construction or just commencing field trials, cannot be considered mobile and/or suitable for consideration for the purpose of this report. They are, however, noted in the report as possibly worthy of more detailed consideration by OWMC in the future.

The characteristics of what constitutes a truly mobile treatment technology for industrial or hazardous waste treatment are not clearly defined. In the broadest sense, almost any technology capable of being transported from one site to another may be considered mobile, independent of scale, mobilization requirements and complexity. Because of this, ES has found it necessary to establish a set of criteria for differentiating between mobile technologies (i.e., those "easily" moved from site to site) and those which are merely transportable. The following criteria were used to make this distinction:

1. The system must be able to be mobilized and brought to a fully operational status within two weeks of site delivery;

2. The system must be capable of cost-reasonable application at the individual site for short operating periods;

3. The system must be applicable for the treatment of high concentration wastes likely to be stored or accumulated at the site (although a number of technologies are suitable for more dilute waste streams, such streams

are more likely to represent high flow wastes requiring permanent emplacement of treatment equipment);

4. The system must be capable of achieving a significant reduction in waste toxicity, mobility or volume with a minimum of subsequent on-site or off-site treatment required; and

5. The system should be suitable for the treatment of actual process waste material. Technologies intended for in-situ waste spillage remediation were not considered appropriate for detailed review unless these could also be directly used for the treatment of industrial process wastes.

During the project, application of the above criteria reduced the number of technologies requiring detailed evaluation within each technology group. In addition, several major waste treatment technology groups were removed from further consideration. Biological systems were dismissed because of the acclimation times which might be needed to achieve full-scale operation conditions. In addition, a number of the more innovative remedial technologies for uncontrolled hazardous waste spills were dismissed as non-applicable for waste materials of interest. Removal of these technologies from further consideration resulted in the listing of four major technology classes. These technology classes are:

1. Thermal Treatment Systems;
2. Physical/Chemical Treatment Systems;
3. PCB Destruction Technologies; and
4. Solidification/Stabilization Technologies.

ORGANIZATION OF THE REPORT

This report has been prepared as directed by OWMC and is intended as a brief overview of the overall mobile technology evaluation project. It is comprised of six sections, the first of which is this introductory section. Sections 2 through 5 describe the survey results for each of the major technology groupings. These major technology groupings are Thermal Treatment Systems, PCB Destruction Processes, Physical/Chemical Treatment Systems, and

Solidification/Stabilization Technologies. The final section of the report contains a review of the findings and the conclusions from this technology evaluation project.

Each of the four major technology groupings sections has been prepared using a standard format to promote readability and ease of understanding. Under each major technology grouping, primary subgroups are identified as appropriate and evaluation of results for each subgroup are presented separately using a tabular format. (For example, two primary subgroups are identified for thermal treatment systems, mobile and transportable technologies, but no primary subgroups were identifiable for PCB destruction technologies.) Each table contains the name of the process and a knowledgable technical representative, a brief description of the major components and processes of the technology, information on the size and commercial demonstration status of currently available units, a review of the current mobility status and the availability of mobile units for the process, and ES' judgement as to whether the technology can be considered as available mobile technology in accordance with the OWMC criteria. For each technology which meets the necessary criteria, an expanded description of the process and its operating history are provided. This description will provide sufficient information for OWMC to decide whether more detailed investigation of the technology for use in the Province is warranted.

SECTION 2
THERMAL TREATMENT SYSTEMS

The thermal treatment systems reviewed as part of this project were categorized as either mobile technologies or transportable technologies. (Results of the ES survey of mobile and transportable technologies are provided in Tables 2-1 and 2-2 respectively.) The primary factors differentiating these two categories are the overall scale of the equipment and the related on-site mobilization requirements. A technology was considered mobile if the complete "treatment package" could be brought to the site on a "reasonable" number of trailers, if no special utilities or structures were required for on-site implementation, and if overall system mobilization could occur within 1-2 weeks. Thermal technologies capable of being mobilized to the site but not able to comply with the mobility criteria were placed in the transportable technology category.

MOBILE THERMAL TREATMENT TECHNOLOGIES

As Tables 2-1 and 2-2 will show, ES' review indicated that only two thermal treatment technologies could be considered as truly mobile and thus suitable for OWMC purposes. These units are the Vesta Technology Rotary Kiln and the Shirco Infrared Furnace. Both of these units, described in greater detail below, have significant limitations in placement and expected performance, and neither technology is currently able to meet the one year commercial demonstration requirement established by OWMC. The Shirco unit (approximately 100 tons per day) requires a large area for on-site mobilization and access since a total of 9 trailers are required. (Some of these concerns may be resolved as the smaller 50 ton per day unit becomes available.) The Shirco system can be considered mobile, however, because only one week or less is required for set-up. In contrast, the Vesta Technology rotary kiln is considerably smaller and easier to mobilize than the Shirco unit, but has a considerably smaller capacity of only one ton per hour. Depending on the

TABLE 2-1

MAJOR TECHNOLOGY GROUPING: THERMAL TREATMENT SYSTEMS
PRIMARY TECHNICAL SUBGROUP: MOBILE TECHNOLOGIES

Technology Name	Name/Telephone Number of Contact Person	Major Components and Processes	Commercial Demonstration Status	Mobility Status	Applicability for CWMC
Westinghouse Electric Corp. Pyroplasma ("Plasma Arc")	Carrie Pennam 412-722-5709	High temperature plasma torch capable of reaching 5000°C or more; waste molecules are pyrolytically dissociated into atomic components. Subsequent cooling and scrubbing may result in some reformation. Application limited to liquid waste streams	Two units are available (1 gpm and 3 gpm) unit; three more in testing stage, but not commercially demonstrated	Should be mobile when commercial units are available. Estimate set-up time of 2-3 days. Torch and related components can be mounted on 48' trailer	Not adequately tested or demonstrated for full-scale application
Westinghouse Electric Corp. Electric Pyrolyzer	William Reed 412-722-5303	In a manner similar to Plasma Arc, electric energy is used to convert soils, solids, and sludges to constitutent atoms and synthetic gases (CO,H) at 3000°F	Prototype unit has been built and tested. Full-scale field trials not performed	Entire prototype unit can be contained on two 45' trailers	Not adequately tested or demonstrated for full-scale application
Vesta Technology Mobile Rotary Kiln	Patrick Philips 305-978-1300	Rotary kiln with secondary combustion chamber units comes complete with air pollution controls, monitoring equipment, etc.	Original test burn, January 1987. Initial full-scale application resulted in substantial re-design; operating commercially in Massachusetts	1 ton/hr unit comes on three 8 x 40" over-the-road trailers	Currently successfully operating and applicable, but fails one year operating criteria
Shirco Infrared Furnace	Jim Fowler 214-630-7511	System uses rows of electrically powered silicon carbide rods to heat waste (on conveyor belt) in incineration chamber; volatilized material is combusted in secondary combustion chamber; solids handling of diverse materials has plagued initial demonstrations	Units (approx. 5 ton/hr) operating in Tampa, FL since Jan. 1987 and in Indiantown since Sept; other units available from Shirco or other clean-up contractors; HazTech, Oil and Hazardous Materials and Reidel Env. Systems have purchased units	Basic unit on 9 trailers; 4 are oversized; Shirco currently constructing 50 ton/day unit on 1-2 trailers; set-up time est. 5 days	Available from 3 remedial clean-up firms; no system operating for one full year yet, but soon will be

TABLE Continued

MAJOR TECHNOLOGY GROUPING: THERMAL TREATMENT SYSTEMS
PRIMARY TECHNICAL SUBGROUP: MOBILE TECHNOLOGIES

Technology Name	Name and Telephone of contact person	Major Components and Processes	Commercial Demonstration Status	Mobility Status	Applicability for OWMC
Thermall, Inc. Rotary Kiln	Gordon Blizard 215-834-7909	Thermall is manufacturer of currently operating Vesta Technology unit.	See Vesta Technology New units under construction		
DeToxco	Kelly McMahon 415-432-6609	Mobile Rotary Kiln; DeToxco manufactured EPA's mobile rotary kiln.	Operated periodically 4-5 years; primarily used for feasibility testing; no long-term	Unit comes on 14 standard trailer trucks with est. time set-up of 2-3 weeks	Not commercially available; limited operating data; size and set-up requirements preclude consideration

TABLE 2-2

MAJOR TECHNOLOGY GROUPING: THERMAL TREATMENT SYSTEMS
PRIMARY TECHNICAL SUBGROUP: TRANSPORTABLE TECHNOLOGIES

Technology Name	Name/Telephone Number of Contact Person	Major Components and Processes	Commercial Demonstration Status	Mobility Status	Applicability for OWMC
Roy T. Weston Transportable Rotary Kiln	John Noland 215-430-3103	Rotary Kiln (8' O.D. by 25') with secondary combustion chamber. Rated at 20×10^6 BTU/hr (approx. 7 ton/hr). Air pollution control equipment and other support facilities included	Currently operating since mid-1987 at Superfund site in Illinois	Comes on 25 trailers, some of which are oversized. On-site mobilization approx. 8 weeks	Transportation and mobilization requirements are of too large a scale to allow consideration as mobile technology
ENSCO	Gary Martini 501-223-4125	Similar to above except rated at 35×10^5 BTU/hr	Currently operating at an unidentified RCRA site for approx. two months	Comes on 10-11 trucks with "extensive" on-site construction	See above
Waste Tech Services Fluidized Bed Reactor	Elliott Cooper 303-279-9712	Fluidized Bed Reactor kept in motion by 10 ft/sec air flow - operating temp. between 600-1200°C - bed material is recycled	Fixed unit (22×10^6 BTU/hr) operating in Louisiana - no mobile/transportable units constructed	Not mobile	Not applicable
GA Technologies Fluidized Bed Reactor	Harold Diot 619-455-3000	Similar to above	Unit has only been demonstrated in pilot scale (fixed facility) with capacity of several pounds per hour	Two transportable units are currently under construction	Lack of full-scale equipment and associated operating data indicates no applicability at this time
Surface Combustion Furnace	Val Diaga 419-537-4682	A fixed hearth pyrolytic unit including refractory-lined batch furnace, secondary combustion chamber and heat recovery unit. Manufacturers only - division of Midland-Ross	A number of these units have been manufactured but none of these are mobile	A 2000 lb/batch prototype unit is available which can be mobilized (is pre-wired and skid mounted)	No history of mobile application - not applicable
International Waste Energy Systems Rotary Kiln	Robert Bloom 314-389-7275	Rotary kiln with fixed secondary combustion chamber rated 50×10^6 BTU/hr	Commercial fixed units are built and have been operating five years. A transportable unit can be modelled after fixed unit	Design calls for 30 trailers some oversized - currently being constructed for Chemical Waste Management, Inc.	No mobile/transportable units are available and no operating data are available - not applicable

N/A

TABLE 2-2, Continued

MAJOR TECHNOLOGY GROUPING: THERMAL TREATMENT SYSTEMS
PRIMARY TECHNICAL SUBGROUP: TRANSPORTABLE TECHNOLOGIES

Technology Name	Name/Telephone Number of Contact Person	Major Components and Processes	Commercial Demonstration Status	Mobility Status	Applicability for OWMC
John Zink Co. Rotary Kiln	Dr. R. Martin 918-747-1371	Rotary kiln with seacondary combustion chamber - full scale unit to be build rated at 30×10^6 BTU/hr	Pilot-scale available - full-scale transportable unit in design stage - pilot-scale operated periodically for two years	Design calls for 12-15 trailers - all within standard legal size	No mobile/ transportable units built or operated - not applicable
Zimpro Wet Air Oxidation Unit	J. Robert Nicholson 800-826-1476	Aqueous phase oxidation of organic and inorganic materials at elevated temperature and pressure. Basic components of the system include reactor vessel (titanium construction) high pressure pump, heat exchanger, oxygen diffusers, etc.	Three wet air oxidation units are built although only two for commercial operation. One unit in Casmalia, CA recently shut down due to bankruptcy of owner. Other unit being used to regenerate powdered activated carbon	Existing commercial unit is skid-mounted so it is transportable up to 10 gpm size. Substantial on-site facilities are needed for mobilization	Unit is transportable with difficulty. Also, serious concerns have been raised in regard to the applicability of the technology to hazardous waste treatment, especially since substantial treatment capacity will be needed to treat by-product streams - not applicable
Vertech Wet Air Oxidation Process	Fran Ferrarro 303-452-8800	System design very similar to Zimpro unit	Demonstration units limited to 0.7 gpm pilot demonstration unit	Not applicable	Not applicable
National Applied Scientific Systems	Mac McGinnis 214-350-6274	Conveyor Furnace. Technology similar in design and operation to the Shirco Infrared Systems	Lab-scale development unit available in Cincinnati. A full-scale fixed unit is currently available and has been operating for about 3,000 hours on non-hazardous waste. Currently pursuing permit status for hazardous waste	Mobile unit (50 TPD) is still in design stage - transportable unit (200 TPD) has been constructed	No mobile units built or operated - not applicable
Rollins Environmental	Pete Falcon 302-479-2700	An innovative system incorporating features from both a rotary kiln and a fluidized bed. Full scale design calls for 33.5×10^6 BTU/hr unit with 9.5' I.D., 55' long reactor	Existing pilot-scale unit has been used for small scale "concept-testing". Full-scale unit has been designed.	Full-scale unit to be built designed for transport on 20 trailers - some oversized	Unit is still in development stage. Once built should be too large for consideration as mobile technology

TABLE 2-2, Continued

MAJOR TECHNOLOGY GROUPING: THERMAL TREATMENT SYSTEMS
PRIMARY TECHNICAL SUBGROUP: TRANSPORTABLE TECHNOLOGIES

Technology Name	Name/Telephone Number of Contact Person	Major Components and Processes	Commercial Demonstration Status	Mobility Status	Applicability for OWMC
Trade Waste Incineration	Jack McCoy 314-727-5040	Rotary Kiln with secondary combustion chamber rated at 50×10^6 BTU/hr for full-scale	Transportable unit currently being constructed for placement in Sauget, IL for permit testing next summer	No applicable	No mobile/transportable units available or operating - not applicable
International Technology	Kevin Smith 615-690-3211	Countercurrent Rotary Kiln with secondary combustion chamber - unit is 6.5' I.D. by 45' long kiln rated between $30\text{-}56 \times 10^6$ BTU/hr	Currently operating at Cornhusker, NE Army Ammunition Plant since summer of 1987. Soon to be moved to similar Army facility in Louisiana	Unit is transportable on "more than six" trailers. Takes approximately 4-6 weeks for on-site mobilization	Transportation and mobilization requirements of too large a scale to allow consideration as mobile technology

nature and distribution of wastes generated on the province, the Vesta unit may be considered too small for widespread commercial application. Larger units currently under construction may be more applicable.

Shirco Infrared Furnace

Currently, two Shirco infrared furnaces are in operation with two more available and ready for full-scale application. Two major firms involved with the remediation of hazardous waste sites, HazTech Inc. and OH Materials Corp, are currently operating these units in the full-scale. Haztech has been operating one of these units at the Peak oil site (Tampa, FL) since February 1987 and operations have been plagued by major difficulties in handling and feeding waste materials to the furnace. A second application by OH Materials Corp. has been on-going at the Florida Steel site in Indiantown, Florida began in September of this year. This application has been very succesful because the waste materials to be incinerated (i.e., sandy materials) are well suited to the technology. Both of these units, and two others owned and operated by Reidel Environmental Technologies and Shirco themselves, are rated at approximately 100 tons per day (5 tons per hour). Shirco is currently constructing a 50 ton per day unit which will be more readily mobilized than the existing 9-trailer mobile configuration.

The existing mobile system is comprised of four primary components. The primary combustion chamber (rated at 48 x 10^6 BTU/hr) is capable of raising waste temperatures up to 1850°F by exposure to infrared radiant heat provided by horizontal rows of electric powered silicon carbide rods located above the high-temperature alloy conveyor belt. The secondary combustion chamber, infrared or gas-fired and capable of reaching temperatures of 2300°F, provides residence time, turbulence and supplemental energy, if required, to destroy gaseous volatiles from the primary furnance. The third component is an emissions control system where particulates are removed in a venturi scrubber, acid vapor is neutralized in a packed tower scrubber, and an induced draft blower draws the cleaned gases from the scrubber into the free standing exhaust stack. The final component comprises a process management and monitoring control center that contains all process and mechanical controls and monitors, including control panels, emissions monitors, motor control centers, and office space.

Because of their tendency to run off the conveyor belt, liquids must be either mixed with solids or injected directly to the secondary combustion chamber. Solids can be fed directly to the primary chamber but must be reduced to a diameter of 1.5 inches. The portable unit has demonstrated permit acceptable destruction removal efficiencies on dioxins, PCBs, volatile/semi-volatile organics, PNA's, and pesticides in soil, solids, sludge and liquid matrices. Estimated costs for operating the system range from $100-$250 per ton. Capital costs for the unit are in the range of $3.5 million.

Vesta Technology Mobile Rotary Kiln

Vesta Technology currently has one mobile rotary kiln unit in operation. This unit was originally constructed to incinerate various solid wastes at a Superfund site in Aberdeen, NC. Operating difficulties experienced during this clean-up required that modifications be made to the original design. These modifications were made by Thermall and the unit has been incinerating nitrobenzene-contaminated soil in Massachusetts for several months. Thermall is currently constructing two larger mobile incinerators for Vesta.

The basic incinerator unit consists of a rotary kiln (150 ft^3 in capacity and 1,300 - 1,700°F) with a secondary combustion chamber (265 ft^3 and 2,250°F @ 2.5-sec. residence time). The existing unit is rated to handle about 5 million BTU/hr (approximately 1 ton per hour of contaminated soil), but new units will be constructed at four times the capacity. Test burns have shown the unit capable of destruction and removal efficiency (DRE) in excess of 99.99%.

Solids entering the Vesta rotary kiln should be shredded or ground to a maximum size of 3/4-7/8". Solids can be fed through either a hopper or belt conveyor. The units are delivered to the site on three 8 by 40 foot trailers and can be mobilized in one day. An air pollution control system is contained on one of the trailers and consists of a flue gas cooler (quench to 1000°F) and a venturi and packed bed scrubber followed by a demister and the off-gas stack. Estimated costs for treatment of contaminated solids and soils range from $250-$400 per ton.

SECTION 3
PCB DESTRUCTION PROCESSES

As part of the 1982 "Survey of Mobile Treatment Facilities for Special Wastes," three manufacturers/operators of mobile PCB chemical destruction facilities were identified. These included:

- Acurex PCB Destruction Unit
- Sunohio PCBX Process
- PPM PCB Destruction Unit

Results of the ES survey of PCB destruction processes are provided in Table 3-1. The table shows that the three technologies mentioned above are still commercially available.

A description of these processes, their mobility, and the availability of equipment can be found in the previous survey report. No significant changes have occurred since completion of the previous report, in either process chemistry or equipment size and configuration. The availability of the Acurex technology, however, has been diminished because the system was purchased and is currently being operated by Chemical Waste Management, Inc. At this time, the only on-going application of this technology is at the Chemical Waste Management facility in Model Cities, New York. The system is currently operating on a fixed, skid-mounted unit. The commercial availability of the process and/or the steps necessary to obtain licensing and subsequent wide-scale use of the system are unclear. Chemical Waste Management is not actively pursuing the mobile PCB destruction market at this time.

TABLE 3-1

MAJOR TECHNOLOGY GROUPING: THERMAL TREATMENT SYSTEMS
PRIMARY TECHNICAL SUBGROUP: PCB DESTRUCTION TECHNOLOGIES

Technology Name	Name/Telephone Number of Contact Person	Major Components and Processes	Commercial Demonstration Status	Mobility Status	Applicability for CWMC
Chemical Waste Management Chemical PCB Destruction Process	Dr. George Nassos 312-218-1500	This technology is actually the old Accurex Process which was purchased by Chemical Waste Management (see 1982 report)	Only one facility is currently operating and has operated for over one year at Model Cities, NY	Existing system is skid-mounted but can be easily mobilized	Applicable for PCB destruction if equipment can be made available
PPM, Inc. Chemical PCB Destruction Process	Keith White 405-528-8371	Previously described in 1982 report	Permitted and commercially available in the full-scale since March 1982	Completely mobile	Applicable as indicated in 1982 report
IT Corporation KPEG PCB Treatment in Hydrocarbons	John P. Woodyard	Dechlorination achieved by mixing KOH with a solvent mixture including polyethylene glycol, DMSO and other solvents under a nitrogen atmosphere	Periodic full-scale applications over past two years	Mobile unit is available and has been used in several applications	Fundamentally similar to other chemical PCB destruction technologies applicable
SunOhio PCBX Process	Bob Reno 216-452-0834	Previously described in 1982 report	Fully permitted in US for mobile applications since 1981	Completely mobile	Equipment not currently available. Applicable as indicated in 1982 report
American Toxic Disposal Vaporization Extraction System	William Meenan 312-336-6067	Basically a volume reduction system to separate concentrate PCB onto fine solids which can subsequently be separated and sent to treatment	One transportable unit is currently available and has been used for field trials	Unit built on five mobile trailers has been moved. Mobility between sites has not been adequately demonstrated	Unit has not been adequately demonstrated in full-scale applications

NEW PCB DESTRUCTION TECHNOLOGIES

In addition to these three technologies, two additional processes for handling PCBs and PCB contaminated solids have been identified and are discussed briefly in Table 3-1.

American Toxic Disposal Volatilization Extraction System

American Toxic Disposal has developed as a system to extract and concentrate PCBs and other refractory organics from contaminated soils and other solid materials. The system relies on vaporization of these materials at 250-350°F in an extractor followed by adsorption and subsequent collection of fine particulates containing most of the vaporized material. Coarse materials with low levels of contamination are discharged separately. This system is not considered feasible for wide-spread mobile application because of transportation requirements and the limitations in equiment availability. In addition, the system is not applicable for PCB-contaminated liquids and has not been adequately demonstrated on the commercial scale at this time.

IT Corporation KPEG PCB Treatment

There is, however, a new chemical PCB destruction technology which appears to have a strong potential for widespread commercial development as a mobile technology. This process has been recently acquired by IT Corporation. The process and associated full-scale mobile treatment system were granted a permit by USEPA Region II (New York, New Jersey) and by New York State in 1985. It is currently scheduled for a national TSCA mobile treatment permit demonstration in the near future. Since that time, the one existing mobile unit has treated over 6,000 gallons of PCB-contaminated transformer oils and over 20,000 gallons of dioxin-contaminated waste oil under a variety of contracts. In one of the early demonstrations in Butte, Montana, at the Montana Pole Superfund site, approximately 9,000 gallons of dioxin-contaminated waste oil were processed over a two-week period. Other tests with the mobile unit on oils and gas line condensate have shown the process to be effective in reducing PCB concentrations from 150 ppm to below 2 ppm.

The reagent for the oil treatment process consists of two components: a solid component potassium hydroxide (KOH) and a mixture of liquid reagent materials. The proportions of these reagent components are varied to meet the needs of a particular decontamination problem, primarily due to considerations of viscosity and reactivity.

The KOH is first loaded into the reaction tank in solid form. It is mixed in the reaction tank with polyethylene glycol (PEG) and dimethylsulfoxide (DMSO), and other solvents are then added, followed by the contaminated oil. The reagent is then drawn into the recirculation line of the reaction tank and crushed by the mixer into a powdered form which flows easily. Nitrogen is drawn from the vapor space at the top of the reactor for the conveying process.

The mixture is slowly heated using an on-board boiler/heat transfer system. The oil/reagent mixture continues to heat until a predetermined temperature is reached. The mixture is then allowed to recirculate through the heat exchanger until analysis of the oil indicates that the PCB content is less than 2 ppm. The oil is then cooled by circulating it through coolers until the oil/reagent mixture reaches the desired temperature.

The reagent is allowed to settle over a period of several hours, providing a well-defined phase separation from the oil. The oil phase is then withdrawn and stored for any additional filtration or pretreatment for subsequent use. Several tests of the treated mineral oil product have shown the oil to be suitable for reuse as transformer oil, although other tests have shown that oil quality prior to treatment can impact its reusability.

The waste reagent is a mixture of potassium chloride (KCl), unreacted reagents, and small quantities of dechlorinated biphenol. The mixture represents only around 1 to 5 percent of the treated product and is currently being disposed of by incineration. Testing is being conducted to determine the feasibility of solidification for landfill disposal or delisting as a hazardous waste.

After receipt of the national TSCA permit for mobile treatment for PCB, IT plans to construct several additional units for various fluid types, including mineral oil and waste oil. Wide-spread commercial application of the technology is expected in approximately one year. Nevertheless, because of the full-scale demonstrations already conducted, this technology appears applicable for consideration by OWMC. Equipment availability is a limiting factor at this time.

SECTION 4
PHYSICAL/CHEMICAL TREATMENT SYSTEMS

Physical/Chemical Treatment Systems comprise a broad range of technologies designed to change the chemical form or phase of contaminants. For organic molecules changes in chemical form are often related to oxidative or hydrolytic type mechanisms which cause a disruption in the structure of the molecule. Often, this will result in either a decreased toxicity or increased biodegradability of the compound. Changes in chemical form for inorganic species often result in some change in phase. This involves removal of the contaminant from the original medium into a more concentrated, more easily handleable form. Common mechanisms for changes or separation in phase include precipitation, filtration of semi-solids or liquids to remove solids, or adsorption onto surfaces or resin.

A large number of suppliers were found who provide equipment and services for the physical/chemical treatment of wastewaters and industrial/hazardous wastes. Unfortunately, most of this technology is primarily applicable to the treatment or concentration of dilute process waste and wastewaters. Few applicable and mobile technologies exist for the destruction/detoxification of concentrated materials. Also, and in keeping with the results of the original 1982 study, few suppliers market their products as being mobile but many claim that these technologies can be easily mobilized. This claim is certainly reasonable and appropriate. However, for the purpose of this report, Engineering-Science's review has been limited to those suppliers who are currently capable of providing truly mobile equipment and who have experience in the active application of this equipment.

Several physical/chemical technologies with potential applicability to OWMC activities have been identified. For discussion purposes, these have been categorized into four groups: Phase Separation Technologies (Table 4-1); Solids Extraction Technologies (Table 4-2); Solids Handling/Filtration Technologies (Table 4-3); and Carbon Adsorption (Table 4-4).

As discussed below, only two phase separation technologies were found to meet or even approach OWMC acceptability criteria. No solids extraction technologies were found to be acceptable, and thus they are not examined in any further detail.

In contrast, a substantial mobile treatment capability was found for the solids handling/filtration technologies. However, since the available technologies basically comprise truck or trailer-mounted traditional centrifuges or belt and plate and frame filter presses, detailed descriptions of this equipment were not judged necessary and are not included in this report.

Mobile carbon adsorption technology is also available from several suppliers, of which the Calgon Corporation can be considered representative. Although this technology is not likely to be applicable to many of the hazardous waste streams of concern to OWMC, a description of Calgon's equipment is provided as being representative of the "state-of-the-art" in mobile adsorption technology.

PHASE SEPARATION TECHNOLOGIES

Although a number of phase separation technologies are potentially applicable to OWMC, only two are sufficiently demonstrated in the commercial marketplace to allow serious consideration. These include Envirochem Waste Management Mobile System and a variety of mobilized equipment available through Radian Corporation and its Rexnord subsidiary.

TABLE 4-1

MAJOR TECHNOLOGY GROUPING: PHYSICAL/CHEMICAL TREATMENT SYSTEMS
PRIMARY TECHNICAL SUBGROUP: PHASE SEPARATION

Technology Name	Name/Telephone Number of Contact Person	Major Components and Processes	Commercial Demonstration Status	Mobility Status	Applicability for OWMC
ECOLOCHEM Mobileflow Water Treatment	Richard Smallwood 804-446-0004	Truck-mounted pressurized vessels containing various resin, adsorbent or filtration materials. A variety of unit operations can be carried out in any sequence including deoxygenation, filtration, demineralization, granular carbon adsorption. Reverse osmosis units are also available.	Numerous units in various configurations for several years. Wide-scale commercial applicability	Complete treatment system package up to 400 gpm is configured in 60' truck - on-site pad construction required - skid-mounted units available	Units are used and best suited for production of high quality waste - not suited for concentrated waste - little applicability to OWMC
Andco Environmental Processes	Gary Peck 716-691-2100	Electrochemical precipitation/coagulation of metals. Solution passes through parallel metal plates. Added ferous iron is precipitated - other heavy metals are co-precipitated. Neutralization, equalization, cyanide destruction, filtration (plate and frame, multi-media) and steam drying of solids available.	Over 200 systems worldwide but only one in fixed facility application	Full-scale mobile units have not been constructed but could be developed in the 1-150 gpm range - mobile pilot units available	Units are not applicable for mobile demonstration
Envirochem Waste Management	Jerry Deakle 919-362-9101	Acid/alkali neutralization, precipitation, sand filtration and solids dewatering for inorganic waste streams	Mobile unit has been used periodically over past year. Process chemistry well demonstrated	One mobile unit is available and second unit being considered. Completely mobile on a 45' truck	Applicable technology for variety of inorganic waste streams
Bird Environmental Systems Model 400	Neil Policow 617-668-0400	Basic unit for alkaline precipitation of heavy metals andd subsequent solids separation via filtration and centrifugation	Full-scale equipment and process well demonstrated - no demonstration of mobile technology	First mobile unit to become available by end of year	Not demonstrated in mobile application - not applicable
URS Corp. Volume Reduction/Phase Separation System	Jimi Mills 415-770-0254	Proprietary batch system for fluoride and heavy metal removal from concentrated plating solution	Current full-scale operation at 150,000 gallons per year but only operating for four months	Newly developed mobile system contained in 48 foot trailer	Existing data are not sufficient to allow engineering evaluation of the technology

TABLE 4-1, Continued

MAJOR TECHNOLOGY GROUPING: PHYSICAL/CHEMICAL TREATMENT SYSTEMS
PRIMARY TECHNICAL SUBGROUP: PHASE SEPARATION

Technology Name	Name/Telephone Number of Contact Person	Major Components and Processes	Commercial Demonstration Status	Mobility Status	Applicability for OWMC
Radian Corp. Mobile/Skid-Mounted Equipment	Dick Osantowski 414-643-3050	Substantial capabilities in a broad range of mobile/skid-mounted physical/chemical treatment system. Mobile equipment includes carbon columns, clarifiers, various filters, electrodialysis, microscreens, RO, belt-filters, etc. "Flagship" capabilities include the treatability van (a pilot-scale test unit) which was recently used to treat high concentration leachate at a Superfund site	A variety of mobile equipment has been used at various sites since early 1970s. Equipment used mostly in range of 25-100 gpm	The treatability van is trailer-mounted and completely portable - a variety of other units have been mobilized on flat-bed trucks/trailers	Radian systems are built primarily for treatment of dilute wastes and wastewaters. Only a limited number of facilities currently exist. Equipment applicable for the following processing steps in the 25-100 gpm range: - GAC adsorption - Precipitation - Flocculation - Solids dewatering. Skid-mounted units are available in larger sizes
Tetra Engineered Systems HDS System	L. Brewsatori 800-327-7817	High Density Sludge (HDS) System. A proprietary technology based on recycle principles and pH modification to create a denser sludge than normally formed through hydroxide precipitation of metals - includes two neutralization tanks, two clarifier tanks and patented unit	Several permanent and fixed units operating since 1979	One "batch" transportable unit custom-built for client - one pilot scale unit available - 8'x40'truck - set-up in 72 hours	System is applicable for waste streams > 50 ppm metals. System not adequately demonstrated in mobile application at this time - although there is adequate operating data from fixed units - potentially applicable
Tetra Engineered System Lectro Clear Process	Larry Hopper 412-264-1600	Proprietary process used for destabilizing colloidal and emulsified suspensions - H_2 bubbles as formed by electrolysis causing flocculation of oil	Used at several installations for over one year	Recently constructed truck-mounted mobile unit is available	Strictly a physical separation emulsion breaking process not suitable for concentration wastes - subsequent treatment of recovered oil necessary

TABLE 4-1, Continued

MAJOR TECHNOLOGY GROUPING: PHYSICAL/CHEMICAL TREATMENT SYSTEMS
PRIMARY TECHNICAL SUBGROUP: PHASE SEPARATION

Technology Name	Name/Telephone Number of Contact Person	Major Components and Processes	Commercial Demonstration Status	Mobility Status	Applicability for OWMC
Industrial Innovations, Inc.	Alfred Abila 209-462-8241	A patented system employing centrifugation and vacuum application to separate oily sludges	Number of units of varying sizes and flows are available and operating	Centrifuge units are available on 40' vans	Limited application to OWMC waste streams - mostly a pre-treatment not addressing waste disposal

TABLE 4-2

MAJOR TECHNOLOGY GROUPING: PHYSICAL/CHEMICAL TREATMENT SYSTEMS
PRIMARY TECHNICAL SUBGROUP: SOLIDS EXTRACTION TECHNOLOGIES

Technology Name	Name/Telephone Number of Contact Person	Major Components and Processes	Commercial Demonstration Status	Mobility Status	Applicability for OWHC
Tetra Engineered Systems Oil Sludge Treatment Process (OSTP)	Steve Watkins 1-800-327-7817	Use proprietary non-hazardous material to extract/release oily material	Two full-scale units built and operating for 6 mos.	1 mobile unit available; off-loaded on concrete pad at site; 7 days mobilization required	Mostly pretreatment and non-hazardous waste application; mobile unit not adequately demonstrated
Monarch Environmental System Hydrocarbon Extraction Process (HEP)	Bob Tarvea 609-227-4711	Solvent extraction of hydrocarbons and subsequent solidification; primarily suited for soils and sludges	System under development; lab/pilot-scale data only	Prototype mobile system under construction	Not demonstrated or applicable
MTA Remedial Resources	Stan Rickard 303-279-4255	Applicaton of froth flotation (derived from mining industry) to wash/extract contaminated soils and sludges	In developmental/pilot-scale testing stage	No mobile technology	Not applicable
Resources Conservation Co. Basic Extractive Sludge Treatment Process (BEST)	Larry Weimar 301-596-6066	Use of an aliphatic amine to break oil water emulsion; heating of solvent separates water and oil/solvent phase; solvent recovered by steam stripping; dry solids and and reusable oil produced	A 100 ton/day full-scale application recently completed in Georgia	System transportable on 10 trailers; substantial mobilization required	Transportation/on-site mobilization requirements too large to consider as mobile technology
US EPA Mobile Systems for Solids Extraction	John Brugger USEPA Edison, NJ	2 systems for cleansing of excavated soils contaminated by spilled or released hazardous substances. Units are: water-knife stripping and soaking unit-rotating drum; and 4-stage countercurrent extractor (4 reactor stages)	Both units "one of a kind"; used by EPA for R and D purposes on several occasions	Both truck-mounted; completely mobile	No history of commercial development; limited practical application potential

TABLE 4-2 (Continued)

MAJOR TECHNOLOGY GROUPING: PHYSICAL/CHEMICAL TREATMENT SYSTEMS
PRIMARY TECHNICAL SUBGROUP: SOLIDS EXTRACTION TECHNOLOGIES

Technology Name	Name/Telephone Number of Contact Person	Major Components and Processes	Commercial Demonstration Status	Mobility Status	Applicability for CWMC
CF Systems Organics Extraction System	Thomas Cody 617-492-1631	Solvent extraction technology using liquified gases near their critical condition to remove organic constituents from sludges, solids and liquid wastes; combination of liquified gas extraction/vapor recompression and conventional distillation	Developmental stage; EPA "SITES" demonstration pending	Limited to demonstration unit	Not applicable
Bird Environmental System Models 100, 200 and 300	Neil Policow 617-668-0400	Model 100 - 100 gpm centrifuge Model 200 - 1.5 meter belt filter press Model 300 - combined centrifuge for oil recovery	Standard technology widely used on many industrial applications	Units just mobilized/ being used at first full-scale application	Pretreatment and phase separation only; limited application

TABLE 4-3

MAJOR TECHNOLOGY GROUPING: PHYSICAL/CHEMICAL TREATMENT SYSTEMS
PRIMARY TECHNICAL SUBGROUP: SOLIDS HANDLING/FILTRATION

Technology Name	Name/Telephone Number of Contact Person	Major Components and Processes	Commercial Demonstration Status	Mobility Status	Applicability for OMMC
Pressure Filtration Specialists Inc. Mobile Filtrations	Mike Jump 803-735-1510	Recessed cavity plate and frame filter press; standard solids filtration service; equipment not sold	14 mobile units in operation with over 1 yr operating experience; units range in size from 1 ft^3 - 100 ft^3 capacity	Units truck-mounted; supplied with generators, pumps, compressors, etc.	Application limited to solids drying/volume reduction
Interim Dewatering Services	Craig Godwin 203-261-4458	Mobile dewatering services with 8 belt presses (1-2.5 meter) and 3 filter presses	2.5 yrs. on-site application but few hazardous waste applications	See above - chemical mix tanks included	Broad spectrum sludge dewatering/volume reduction only
Metropolitan Environmental Inc.	Margie Ramsey 419-586-6638	Centrifugation units (with heat) to break oil water emulsion; mobile plate and filter chemical addition as appropriate	Commercial operations since 1984	6 mobile plate and frame filter presses, each housed in 48-foot self-contained trailer (50 ft^3 per 1.5 hr cycle) centrifuge on flat-bed trailer	See above
Tetra Engineering Systems	Larry Hopper 412-264-1600	Belt filter presses (up to 3.5 m) with polymer conditioning tanks; plate and frame filters (up to 38 ft^3/batch)	Widely used for past several years	Skid-mounted and transported to site on flat-bed trailers - 1-week mobilization/concrete pad needed	Mobilization requirements greater than other units providing similar product/service
BVER Inc. Mobile	Jim Volanski 304-387-3225	Recessed plate and frame filter press; chemical conditioning tanks available	Unknown	9 units now available on standard trailer	Limited application

TABLE 4-4

MAJOR TECHNOLOGY GROUPING: PHYSICAL/CHEMICAL TREATMENT SYSTEMS
PRIMARY TECHNICAL SUBGROUP: CARBON ADSORPTION

Technology Name	Name/Telephone Number of Contact Person	Major Components and Processes	Commercial Demonstration Status	Mobility Status	Applicability for OWMC
Carbon Air Services	Tim Peschmann 612-935-1844	Carbon Adsorption Beds 16' long by 6' high by 7' high, capable of treated up to 250 gpm (note: one-of-a-kind metal precipitation and ion-exchange units are available but currently not used - both units as pilot scale)	Numerous full-scale applications since late 1970s	Transported by tractor/trailer - two days to one week for on-site mobilization, skid-mounted	Mostly applicable to contaminated wastewater application - more mobile carbon units are available from Calgon
Calgon Corp. Mobile (Dual-Bed) Carbon Adsorption Unit	Joe Rizzo 412-787-6700	Dual Bed Carbon Adsorbers (approximately 10' high x 10' in diameter) capable of treating approximately 350 gpm - filters provided as appropriate	Widely used - represents the "standard" in mobile carbon adsorption technology	Completely portable on a flat bed truck	Primarily limited to contaminated wastewater applications
Chemical Waste Management "Big Mac"	Mike McKinley	Similar to Calgon Unit	Used periodically over the past several years - well documented	See Calgon Unit	See Calgon Unit

ENVIROCHEM Waste Management

The ENVIROCHEM mobile unit is capable of performing acid/alkaline neutralization, chemical precipitation, sand filtration and solids dewatering (filter press or belt press). ENVIROCHEM's basic unit is mounted on a 45-foot drop deck trailer. No supplemental facilities are required except for possibly an equalization or storage tank. The unit consists of two 500-gallon chemical mix tanks which feed two 1,000-gallon reaction tanks. The tanks can be in series or parallel and can subsequently feed either an 8 x 10 sand filter, a filter press, or a belt filter as appropriate. The unit requires power and air supply, but these can be supplied by portable units. Only 1-2 days are needed for on-site mobilization. The only waste stream produced by the unit which requires additional handling would be filtered solids (sludge). Currently, the product solids are containerized prior to disposal in accordance with the client's request. No supplemental facilities are currently provided for subsequent filtrate treatment.

Currently, only one unit is available and this has only become operational during the past year. To date, two major projects have been successfully undertaken for the neutralization of concentrated acids and precipitation of metals. For concentrated solutions (i.e., acid neutralization), 2,000-3,000 gallons per day can be treated based on a one-shift operation. For dilute solutions and for metals precipitation, 5,000-10,000 gallons per day can be treated.

Radian Corporation - Skid Mounted Equipment Capabilities

Rather than selling a set process or technology, Radian Corp. and its recently acquired susbidiary Rexnord Corp. markets a variety of mobile and skid-mounted treatment trains. Various unit operations which have been mobilized on either truck or trailer-mounted applications include:

- Carbon Columns
- Flocculators/Clarifiers

- o Multi-media Filters
- o Aeration Reactors
- o Deionization/Demineralization Units
- o Anaerobic Reaction Vessels
- o Chemical Feed Systems
- o Dissolved Air Flotation (DAF)
- o Air Strippers

These components have been structured within various mobile treatment systems to accomplish a number of process objectives: physical/chemical hydrocarbon removal from groundwater (1983); soil washing for PCB removal (1985); mercury removal from incinerator quench water (1985); and various physical/chemical treatability tests for surface water at Superfund sites (1986). Essentially, all of this equipment has been constructed on an as-needed basis and was intended primarily for pilot-scale feasibility testing. In addition, Rexnord has developed several full-scale treatment systems for use by others, especially USEPA. Four of the largest "customized" units which have been constructed under USEPA contract include EPA's first mobile full-scale physical/chemical treatment system (sand filtration and GAC; in service since 1972), in-soil grout and chemical injection system (1979-present), and mobile two-stage and four-stage soil scrubber systems.

In terms of existing processing technology (i.e., currently built and available), Rexnord has a 48-foot mobile treatment van containing chemical feed tanks, flocculation/clarification capabilities, activated carbon adsorption vessels, aeration, filtration and air stripping. At this time. only a single unit is available and there are no plans to commercially market these capabilities for industrial waste treatment purposes. The unit is intended primarily for pilot-scale demonstrations and low volume (25-100 gpm) treatability determinations at various hazardous waste sites.

ACTIVATED CARBON

A number of vendors supply mobile treatment technology, and these units tend to be very similar in form and function. The unit available from Calgon Corporation serves as a excellent example of this technology.

Calgon Mobile Treatment System

The Calgon Mobile Treatment Adsorption System has been designed for the removal of soluble organic chemical contaminants from water or wastewater using granular activated carbon products. The system is particularly suitable for applications with low levels of organic contaminants or with flow rates up to 700 gallons per minute per vessel.

The unit is a complete water treatment system, skid-mounted and transported by flat-bed trailer for ease of installation, and is provided with piping for series or parallel operation. It is also provided with pre-assembled piping sections for influent and treated water, utility water and compressed air, carbon transfer and venting operations. Only water and utility connections are required to complete the installation of the Calgon unit.

The adsorber vessels are ASME coded for 75 psig, lined for corrosion resistance and are designed to contain 20,000 lbs of granular activated carbon. Carbon transfer piping allows use of special transfer trailers. At a flow rate of 350 gpm, each adsorber provides 15 minutes contact time. The units are currently mobilized out of Pittsburgh or Houston and are primarily intended to provide emergency clean-up services. There are also limitations as to what types of waste are acceptable. (As an example, PCBs are not acceptable because the Calgon's regeneration furnaces are not permitted for PCB destruction). Reportedly, the unit can be mobilized to the site within 24-48 hours.

In summary, the availability of mobile physical/chemical treatment systems tends to be limited to selected areas such as solids/sludge filtration and adsorption technology related to water treatment. Few systems are available for the treatment of concentrated waste materials. Although much of the technology associated with these physical/chemical processing steps is available and could be mobilized with a minimum of effort, few suppliers are currently in this market and overall development of the industry is expected to be slow.

SECTION 5
SOLIDIFICATION/STABILIZATION TECHNOLOGIES

As shown in Table 5-1, there is currently a very large number of firms marketing solidification technologies. Although such technologies can handle organic waste components, the technology is primarily directed towards the treatment of inorganic materials. In these applications, most of the contractors/suppliers use a variety of formulation and solidification chemicals which are determined to be best suited to the waste to be solidified. Bench-scale and laboratory testing is often required before full-scale application can begin. This pre-testing is necessary to insure that the proper chemical mix is used and that acceptability criteria can be consistently met.

Most of the solidification processes currently available are primarily directed towards in-situ stabilization of semi-solid wastes in lagoons or impoundments. These technologies are usually applied on a "one-time only" basis at various sites rather than via more permanent installations. As a result, most of the available equipment tends to be mobile in nature to be consistent with the needs of a market area, i.e., application for lagoon closure. Such mobile equipment would include "backhoe-mounted" injection and related mixing equipment on truck/trailer-mounted chemical storage and transfer systems. Some vendors, however, supply filtration systems to increase solids content, as well as mixing and other ancillary systems which are more useful for the periodic and small-scale treatment of stored sludges and solids at industrial sites. Applicability in these cases is limited to technology which employ some form of "cement mixer" in the process. Of course, such equipment can be easily incorporated into many of the available processes.

TABLE 5-1

MAJOR TECHNOLOGY GROUPING: SOLIDIFICATION/STABILIZATION TECHNOLOGIES

Technology Name	Name/Telephone Number of Contact Person	Major Components and Processes	Commercial Demonstration Status	Mobility Status	Applicability for OWMC
Chemical Waste Management Mobile Solidification Services	Carl Swanstrom 312-841-8360	Skid-mounted pneumatic chemical/reagent transfer system and pug mill mixer - case-specific mix of chemical reagents	Wide application - numerous remedial clean-up sites	All equipment, including construction equipment for soil excavation, portable on trucks	Primarily for lagoon clean-ups but can be adapted - on-site final disposal common
CHEMFIX Technologies	Tracy Faulkner 504-831-3600	Use of soluble silicates with calcium based setting agents	Six units currently working in field in mobile applications	All equipment, including mixers, pumps, conveyors, bulk chemical storage, etc. trailer mounted	See above
Waste Chem Corporation Volume Reduction Solidification System	Tom McCord 201-599-2900	Process basically involves an evaporation step followed by mixing with asphalt and subsequent extrusion-off-gas treatment supplied by condenser (scrubber of GAC and filters)	"Numerous" fixed facilities have been built and are in operation - first developed over 20 years ago	First mobile unit (on two flat-bed trailers) currently scheduled for mid-1988 - 120 l/hr capacity	Not applicable at this time
Envirite Field Services PF-S System	Jim Deal 215-825-5877	Mixing of proprietary pre-conditioning agents followed by injection of common solidification chemicals such as cement, lime, flyash, etc.	In commercial operation approximately three years	All storage, mixing and chemical transport equipment is portable	Primarily for lagoon/impoundment clean-ups but can be adapted
Envirite Field Services VR/S System	See above	Pre-filtration of solids on plate and frame filter followed by application of PF-S process	Same as above	Same as above	Applicable to high solid streams - does not address soluble components

DMT 1:10

TABLE 5-1, Continued

MAJOR TECHNOLOGY GROUPING: SOLIDIFICATION/STABILIZATION TECHNOLOGIES
PRIMARY TECHNICAL SUBGROUP:

Technology Name	Name/Telephone Number of Contact Person	Major Components and Processes	Commercial Demonstration Status	Mobility Status	Applicability for OWMC
Envirochem Waste Mgmt.	Jerry Deakle 919-362-9010	Basic solidification process using skid-mounted (or bulk-trailer mounted) pneumatic conveyor systems, backhoes, mixers and other in-situ injection equipment	In commercial operation about 7 years	Similar to other systems for lagoon/impoundment closures	May be adaptable
Hazcon, Inc. Solidification Process	Ray Funderburk 713-391-1085	Addition of proprietary chemical "chloronan" makes solidification process more amenable to organic constituents - all systems include pre-screening	In commercial operation aproximately 3 years	3 mobile systems available: 1 batch system 2 continuous flow systems with pug mill (all components are truck mounted)	Applicable
International Waste Technology (IWT) Polymeric Solidification Process	Jeff Newton 316-262-1338	Polymer processes to create macromolecules resistant to acid and other deteriorating factors. Macromolecules made of interconnecting polymeric molecules	Process under development but still only pilot-scale demonstration on-going	Equipment mobility similar to other solidification systems	Not adequately demonstrated
Velsicol Chem. Company	Kunar Trevidi 901-345-1788	Basic solidification technology with proprietary additives and procedures - mostly applicable to organic sludges	Initial work in 1981-82 suspended until present - one 20-million gallon lagoon clean-up performed	Similar to other vendors - truck/trailer mounted equipment	Potentially applicable - site specific testing would be necessary
Chem-Met Services	Bob Colburn 313-282-9250	Uses lime kiln dust almost exclusively	No information available	Similar to above	Primarily suited to lagoon impoundment closure - could be adapted to industrial waste streams
Enreco, Inc.	Dale Musser 806-379-6424	Applies commonly used solidification agents	In business 5 years and has performed over 160 projects	Similar to above	Primarily suited to lagoon/impoundment closures - could be adapted

There is little variation among the various solidification processes which are now available. Consequently, it is not possible to select the "best" process for a given application because of the waste-specific nature of the chemical reactions involved. Furthermore, many of the technologies which now appear primarily directed towards the lagoon/impoundment closures can easily be adapted to smaller volume, waste-specific applications. Consequently, review of mobile solidification/stabilization processes can best be summarized by stating that substantial capabilities in mobile technology currently exist. Obtaining these services in Ontario should not represent a significant technical, administrative or economical problem. The problem becomes, rather, that of making the application of this technology suitable with the quantity, diversity and distribution of inorganic waste streams in the Province.

SECTION 6
CONCLUSIONS AND RECOMMENDATIONS

This updated 1987 survey of mobile treatment technologies has shown that a significant number of such technologies exist in a variety of technical areas. Closer examination shows, however, that only very few of these technologies meet OWMC criteria and are worthy of more detailed consideration. Those technologies that are applicable for OWMC purposes tend to be limited primarily to PCB destruction methods and, to a more limited extent, thermal and solidification/stabilization processes.

The availability of chemical destruction methods for PCBs does not represent a significant change from the conclusions of the original 1982 survey. The same technologies are available and practiced, and one additional method is rapidly approaching commercial development. There has, however, been a substantial increase in the number and diversity of contractors supplying solidification/stabilization services. Nevertheless, many of the current procedures used in this area, namely in-situ lagoon and impoundment applications, may have only limited applicability to small-scale industrial waste applications. Several incineration technologies are also potentially applicable. The number of available mobile units is very limited at this time, although this industry can be expected to grow dramatically over the next several years. In addition, the incineration units which are currently being used on the full-scale have very limited operational histories. Many more demonstrations across a wide diversity of conditions will be necessary before this technology can be recommended with confidence for mobile application.

At this time, there appear to be only two suppliers who have adequate capabilities to provide physical/chemical treatment services for the type of

waste of interest to OWMC. These suppliers are Radian Corp. (through their Rexnord subsidiary) and Enviroclean Waste Management. There are, however, substantial limitations in the amount of processing equipment that is currently available from these suppliers. As a consequence, it appears unlikely that any substantial degree of treatment in this area could be supplied with mobile technology. Substantial development will be required before this can become feasible.

Based on these observations and the results of this survey, the following recommendations are proposed:

1. Chemical destruction of PCBs continues to be a viable option for the application of mobile treatment technology. A detailed study should be carried out to determine if use of this technology will have any economic advantage when combined with the planned regional treatment facility.

2. More careful attention should also be given to the application of mobile solidification technologies. This may represent a cost-effective option for small industries generating significant quantities of inorganic waste sludge in combination with fixed treatment facilities. The lack of available physical/chemical waste treatment capacity will limit the potential applicability of solidification as a component part of a comprehensive mobile waste treatment system.

3. Because of poor process and equipment availablility, mobile physical/chemical treatment of concentrated waste streams should not be pursued at this time.

4. On-going developments in the field of on-site incineration technology should be carefully monitored. Although significant application of this technology appears to be years away (primarily due to equipment manufacturing limitations and lack of public acceptance), it is

possible and indeed likely that operation of a mobile incineration facility may be a feasible and cost-effective option within the next 5 to 10 years. On a Province-wide basis, however, consideration must be given to whether use of a mobile incinerator will provide the necessary waste treatment capacity.